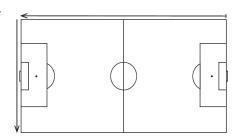
### Vectors

- 1. Sketch the following vectors
  - a. 8.5 m/s [35° W of N]
  - b. 12 m/s [58° S of E]
- 2. Calculate the resultant displacement of a hiker who travels 8.0 km [E] and then 4.0 km [S]. Include a vector diagram.
- 3. Discuss why [60° S of W] and [30° W of S] may be used to represent the same vector.
- 4. A cat travels 9.5 km [S], 2.0 km [N], and 5.0 km [W]. Draw a labelled vector diagram and determine the resultant displacement of the cat.
- 5. A soccer player runs the sidelines of a soccer pitch of dimensions 100.0 m by 65.0 m. What is the distance travelled and resultant displacement of the player?



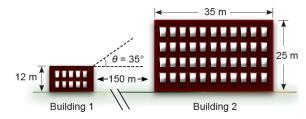
#### Relative Motion

- 6. What is the resultant velocity of an airplane that travels through the air at 152 km/h [E] if there is a 40.0 km/h [S] crosswind? Include a vector diagram. What direction should the plane head if the pilot wants to end up directly East of the starting point?
- 7. A ship has a velocity of 12.0 km/h [W] with respect to the water. The current flows at 4.0 km/h [N]. Calculate the resultant velocity of the ship. Include a vector diagram.
- 8. The captain of a boat attempts to travel due East across a river that is 45.0 m wide. If the boat can travel at 5.0 m/s with respect to the water and the current flows at 3.0 m/s [S], how long does it take to travel directly across the river?
- 9. A cruise ship is travelling North. A passenger on the deck of the ship walks directly west with respect to the ship. Sketch a diagram of the velocity of the passenger with respect to the water.
- 10. Mark rode his personal watercraft at a constant speed of 25 km/h [N] across a river with a current of 12 km/h [E]. What is Mark's velocity relative to the bank?

- 11. A small plane flies with a speed of 225 km/h relative to the air. The plane experiences a crosswind blowing 55 km/h [E].
  - a. What heading must the pilot use to fly due North?
  - b. What is the speed of the plane relative to the ground?
  - c. How long would it take the plane to reach an airport 575 km [N] of its starting point?

# Projectile Motion

- 12. A toy car rolls off a lab bench (h = 1.2 m) at 3.0 m/s. How far would it travel horizontally before hitting the ground?
- 13. A soccer ball is kicked with a speed of 21.0 m/s at an angle of 37.0° above the horizontal. Calculate the time of flight and the maximum height.
- 14. A projectile is thrown from the top of a 30.0 m building. The initial projectile speed is 12.0 m/s and it is thrown upwards at an angle of 20.0° above the horizontal. Determine the projectile's range.
- 15. A cannon sitting on a 520 m high cliff, fires a cannon ball at 110 m/s, 65° below the horizontal. Calculate the impact velocity of the cannon ball.
- 16. A projectile is launched from the roof of a school (h = 9.5 m) and hits the ground 2.4 s later, after travelling 28 m horizontally. What was the initial velocity of the projectile? ()
- 17. Juliet throws a letter to Romeo who is on a balcony 3.0 m above the ground. If she throws it with a velocity of 6.4 m/s [45° above the horizontal] can the letter reach him?
- 18. A fish at the surface of a pond shoots a stream of water at a bug 0.26 m above the water with a range of 3.0 m. If the initial velocity of the water is 6.0 m/s at 30.0° above the horizontal, does the water hit the bug?
- 19. A projectile launcher launches a snowball at a velocity of 45 m/s [35° above the horizontal] from the top of building 1. Does the snowball land on top of building 2? Support your answer with calculations.



20. A biker hits a jump on his motorbike at 27.0 m/s 35° above the horizontal. The jump is 120.0 m above the ground. The biker lands on a platform of unknown height 145.0 m away from the cliff. How high is the platform that the biker lands on?

21. Three projectiles are launched at different angles, 25°, 43°, and 75° respectively, but with the same initial speed. All the projectiles are launched from and land on the ground. A student argues that the projectile launched at 43° will have the longest flight time because it has the largest range. Is the student correct? Explain.

## Momentum and Collisions

- 22. A 2.0 × 10<sup>3</sup> kg car travelling at 20.0 m/s [N] is struck at an intersection by a 2500 kg pickup truck travelling at 14.0 m/s [W]. If the vehicles stick together upon impact, what will be the velocity of the car-truck combination immediately after the collision?
- 23. A 0.400 kg grenade is stationary when it explodes into three fragments. One 0.237 kg fragment (A) goes off at 19.7 m/s [35° S of E]. A second fragment (B), of mass 0.066 kg, travels due North, while a third fragment (C), of mass 0.097 kg travels due West. Determine the velocity of the second and third fragments after the explosion.
- 24. An 86.4 kg defenseman skating at 2.46 m/s [S] collides with an 84 kg centreman skating directly West. The players fall in a tangle and slide at 1.57 m/s [52° S of W]. What was the initial velocity of the centreman?
- 25. Two identical curling stones (m = 19.5 kg) collide. Stone A is initially at rest and travels 3.2 m/s [30.0° W of N] after the collision. Stone B was travelling 5.0 m/s [N] before the collision. What is the velocity of stone B after the collision?
- 26. Two billiard balls with identical mass collide (m = 0.160 kg). Prior to the collision, ball A was travelling 2.20 m/s [S] and ball B was travelling 3.10 m/s [W]. After the collision, ball A was travelling 2.56 m/s [14.0° N of W]. Determine the velocity of ball B after the collision.
- 27. A 1200.0 kg car (A) strikes a stationary 1350.0 kg car (B) off centre from behind. Accident analysis showed that after the collision, car B moved at 8.30 m/s [35° N of E], and car A moved 12.8 m/s [53° N of W]. What was the velocity of the car just before the collision?
- 28. Two bumper cars collide and stick together. Car 1 (m = 150 kg) is travelling 3.5 m/s [N] when it strikes car 2 (m = 95 kg), travelling 2.5 m/s [E]. What is their combined velocity after colliding?
- 29. A 0.058 kg firecracker that is at rest explodes into three fragments. A 0.018 kg fragment moves at 2.40 m/s [N] while a 0.021 kg fragment moves at 1.60 m/s [E]. What will be the velocity of the third fragment?

30. The police are investigating an accident. They have determined that the mass of car A is 2275 kg and was traveling North before the collision, while car B has a mass of 1525 kg and was traveling East just before the collision. Accident analysis has determined that the cars, when they were locked together, had a velocity of 31 km/h [43° N of E]. If the speed limit was 35 km/h on both streets, should one or both cars be ticketed for speeding?

# Answers

1	a) 8.5 m/s 35° 58° b) 12 m/s
2	d = 8.9 km [27° S of E]
3	The directions are the same, the angles are just measured from different places.
4	d = 9.0 km [56° S of W]
5	distance = 165.0 m displacement = 119 m [33° S of W]
6	v = 157 km/h [15° S of E]; 15° N of E
7	v = 12.6 km/h [18° N of W]
8	v = 4.0 m/s [E]; t = 11 s
9	
10	v = 28 km/h [64° N of E]
11a	14° [W of N] or 76° [N of W]
11b	v = 218 km/h
11c	t = 2.64 h
12	t = 0.49 s; d <sub>x</sub> = 1.5 m/s
13	t = 2.58 s; d <sub>y-max</sub> = 8.14 m
14	t = 2.93 s or -2.09 s; d <sub>x</sub> = 33.0 m
15	$v_{y2}$ = 140 m/s; v = 150 m/s [72° below horizontal]
16	$v_x = 12 \text{ m/s}; v_{y1} = 7.8 \text{ m/s}; v_1 = 14 \text{ m/s}$ [34° above horizontal]
17	no; d <sub>y-max</sub> = 1.0 m

18	no, it misses; $t = 0.58 \text{ s}$ (to travel 3.0 m horizontally); $d_y = 0.1 \text{ m}$
19	yes; $d_x$ must be between 150 m and 185 m; $t = 0.56$ s [going up] or $t = 4.7$ s [coming down]; $d_x = 21$ m [going up] or $d_x = 170$ m [coming down]
20	d <sub>y</sub> = -109 m; h = 11 m [above ground]
21	no; t is not the only factor involved when calculating range.
22	v = 12 m/s [49° N of W]
23	v <sub>F2</sub> = 41 m/s [N]; v <sub>F3</sub> = 39 m/s [W]
24	v <sub>c</sub> = 4.1 m/s
25	v <sub>B2</sub> = 2.7 m/s [54° N of E]
26	v <sub>B2</sub> = 2.89 m/s [78° S of W]
27	v <sub>A1</sub> = 15.6 m/s [N]
28	v <sub>2</sub> = 2.35 m/s [66° N of E]
29	v = 0.94 m/s [380 S of W]
30	v <sub>A1</sub> = 35 km/h [N]; v <sub>B1</sub> = 56 km/h [E]